larger land mammals of the world, and the peculiar and interesting indigenous faunas of many small islands may still be permanently preserved by prompt protective measures, and not merely state and national action, but as soon as the war is over, international agreements to bring about cooperation for these ends are urgently needed. Future generations will look back on the present time as an age of shameful vandalism as far as nature is concerned. Our present imperfect and feebly carried out efforts for the preservation of the most interesting and wonderful of the birds and mammals that still survive are insufficient. They must be on a larger scale and more effectively and intelligently conducted than at present. It should be the effort of every scientific man, and especially of the larger and more influential scientific associations, to bring the seriousness of the situation to public notice and to insist on prompt action. This is vastly more important for zoology to-day than the naming of new subspecies or than disputes over the validity of scientific names, and should put an end to complaints over small personal and temporary inconveniences which regulations of the greatest importance may incidentally occasion. WILLARD G. VAN NAME

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FUNDAMENTAL EQUATIONS OF MECHANICS

TO THE EDITOR OF SCIENCE: We are greatly interested in the contribution to the teaching of elementary dynamics made by Professor Kent in his letter to SCIENCE appearing in the issue of March 19, in which he presents as the fundamental equation of mechanics $V = FTg/W$, where F, T and W are, respectively, force in pounds, time in seconds and quantity of matter in pounds, g a numerical factor of proportionality and V velocity in feet per second. This equation has the great advantage of avoiding the extremely awkward necessity involved in apparently simpler formulations of the experimental laws under consideration, of defining force in terms of mass, as so many of the more conservative physicists insist on doing, or of defining mass in terms of force, a thing which many of these conservative physicists seem to consider as the only alternative and which all engineering writers appear to disclaim with equal vehemence.

There can be no doubt of the difficulty of measuring quantity of matter, that is comparing the quantities of matter in two bodies, one of which is taken to be a standard, except by resorting to forces acting upon them. On the other hand, there can be no doubt of the inadvisability of attempting to preserve an international prototype force instead of a prototype quantity of matter, owing to the probability that secular changes in the elastic properties of material bodies would be vastly greater than changes in their quantity of matter. To be sure it would be possible to define the international prototype force in terms of the gravitational relation of a given body to the earth, but this would be open to the same objection as the one that was raised in regard to measuring the quantity of matter in a body by resorting to forces. We therefore think that Professor Kent has done well to retain force and quantity of matter as equally fundamental.

What seems to us as unfortunate is the necessity of defining velocity in terms of distance and time. Why not regard all dynamical quantities that are sufficiently distinct to be given different names as equally fundamental? Why stop with distance, time, quantity of matter and force? We see no reason for imposing on ourselves such a limitation.

On this principle the equation $F = ma$, to which Professor Kent objects because it is not true unless we make m an arbitrary symbol for W/g, is open also to our objection that a has been defined in terms of other magnitudes, whereas nature has furnished us with a definite acceleration, that of a body under the influence only of its gravitational relation to the earth at sea-level and latitude 45° as modified by its tendency to rise due to the rotational motion, which may well be taken as unit acceleration.

It appears to us that Professor Kent's contention is essentially this: that since the *concept* of force is independent of quantity of matter, distance and time, it is irrational to force people to take their *measure* of force from a dynamical equation involving these three sorts of magnitudes. We should take

our measure of force from some phenomenon more closely related to the concept. What we are conscious of when we lift a pound weight is not the amount of matter in it, but the force upon it.

If this sound reasoning is to be applied to all the concepts of mechanics it will be necessary to modify most of the equations slightly by introducing a proportionality factor. This has already been suggested by Professor Hoskins in a footnote to his review of Maurer's "Technical Mechanics,"[1] but he failed to make the most of his opportunity. We present here a tentative scheme only and the calculated values of a few of the constants. Our choice of fundamental units of velocity and acceleration are, we freely admit, open to the criticism of being ill-considered and off-hand. Still they will do perfectly well to illustrate the method, and certainly they are much better than the units in common use which only tend to cloud the physical entity and reality of the magnitude in question by reference to others more or less closely related. Who that has considered with any care his sensations of a passing express train does not realize that his impressions on the subject "how fast" are much more direct and elemental than any question of "how far" or "for how long"?

We begin then with the units of force, distance, time, quantity of matter and acceleration as defined above and which for our present purpose may be regarded as sufficiently unrelated to be called independent, fundamental units. What definite velocity does nature present to us that we may take as unity? After considering the peripheral and the orbital velocity of the earth and the maximum attainable velocity due to terrestrial gravitation (that of a body falling from the hypothetical "infinite distance"), it seemed well to abandon such gravitational velocities as being dangerously near to our definition of unit force (a totally unrelated concept) and adopt the velocity of light, which is one of the most definite and unalterable things in nature. This unit we call the "speedal," not from any wish to be bizarre, but merely because some name is necessary to show where the idea leads us. 10^{-6} speedals we will call a micro-speedal. We see no real objection to calling it pounds, since we already employ this useful word to designate unit quantity of matter and unit force, but perhaps the present name will serve our purpose better.

[1] SCIENCE, December 4, 1914.

Let $W=$ quantity of matter in pounds,
$S=$ distance in feet,
$T=$ time in seconds,
$F=$ force in pounds.

(Whether these are the same pounds as mentioned above or other pounds seems to be of no importance.)

$V=$ velocity in micro-speedals,
$A=$ acceleration in "gravitals,"

and α, β, γ, δ, etc., be numerical constants of proportionality. We may write the following equations:

$$V=\alpha S/T, \tag{1}$$

$$A=\beta V/T=\alpha\beta S/2T^2=\gamma S/T^2, \tag{2}$$

where it is understood that V in equation (2) is a *change* in velocity and therefore twice the *average* velocity defined by (1). (Initial velocity being zero.)

$$F=\delta WA=\beta\delta WV/T=\gamma\delta WS/T^2. \tag{3}$$

From these three fundamental equations we may derive equations such as

$$FT=\gamma\delta WS/T=(\gamma\delta/\alpha)WV=\epsilon WV \tag{4}$$

and

$$FS=\gamma\delta WS^2/T^2=\gamma\delta WV^2=\zeta WV^2. \tag{5}$$

And from these, as soon as we have established units for momentum M, energy E, impulse I and work Z, and determined the constants in equations like $I=\eta FT$ and $M=\theta WV$, we could derive the equations of momentum and of energy.

The values of the constants may be easily computed. Since one micro-speedal is 1,182.9 feet per second, $\alpha=1{,}182.9$. The equation for an acceleration of one foot per second per second is

$$\frac{1}{32.1740}A=\frac{1}{1182.9}\frac{V}{T},$$

which gives us at once

$$\beta=\frac{32.1740}{1182.9}=.027200.$$

Also $\gamma = \alpha\beta/2 = 16.0870$. The coefficient δ is unity, which is a little unfortunate since it might lead to the erroneous impression that we were *defining* unit force as that force which gives unit acceleration to unit mass. Our choice of unit acceleration has probably been injudicious.

Enough has been given to illustrate the principle which we feel sure ought to commend itself to every one who once grasps the fundamental independence of all dynamical concepts and the strictly proportional nature of the dynamical equations, all of which are merely the algebraic formulation of experimental evidence. In extenuation of our introduction of a new set of numerical constants to be memorized we can only point out that there were many "½'s" "4π's," etc., there already and that we entirely do away with the troublesome and useless subject of dimensions.

The new system is not fully developed as yet, however, and until it is we have found ourselves compelled to make the best of the old one. We dodge the ambiguity in the "ambiguous words 'weight' and 'mass'" by the artifice of defining them. We adopt and we teach the convention that "mass" shall be an exact equivalent for "quantity of matter," and that "weight" means the gravitational *force* upon a mass. We teach that the *measure* of a force (wherever the *concept* of force may originate) may conveniently be defined by the equation $F = ma$. We teach that it is a remarkable law of nature, determined only by experiment, and not to be suspected *a priori*, that the "body factor" in this equation is strictly proportional to the weight for all bodies in the same uniform gravitational field. We point out that pounds-mass and pounds-weight (*i. e.*, pounds-force) are totally different things, and that there are 32.2– of the units of force defined by the equation $F = ma$ in a pound-weight and that therefore all forces deduced in dynamical equations must be divided by 32.2 if we wish to express them in terms of pounds-weight, much as one would reduce centimeters to feet. Conversely, all forces given in pounds-weight must be multiplied by 32.2 before they can be used in dynamical equations. We teach that the fundamental idea of the gravitational constant g is force per unit mass and that it is also of the nature of an acceleration in virtue of the relation $F/m = a$. We hold that dynamics *may* be developed without the introduction of arbitrary constants by the assumption of three fundamental units and defining all the others in terms of these three. We object to Professor Kent's description of a system with four fundamental units as a "foot-pound-second" system instead of a "foot-pound-second-pound" system, and to his ridicule of the "gee-pound" or "slug" in the same letter in which he says, "It has been found convenient to use the letter m instead of W/g." What is the *unit* of m if not the "slug"? We frankly talk about a unit of force called a poundal as a matter of convenience, and we measure it by a defining equation much as we measure a unit of velocity or of work. We consider this term preferable to the "pound-foot-per-second-square," and venture to hope that there may some day be introduced shorter names for the "foot-per-second-per-second" of acceleration and the "pound-foot-square" of moment of inertia.

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ANOTHER STATE PARK NEEDED

TO THE EDITOR OF SCIENCE: Two or three notes of interest have appeared in SCIENCE regarding the new state reservation at Jamesville, Onondaga County, New York, which includes the glacial lake, sometimes known as West Green Lake. This little lake is of especial interest owing to its history as the site of the plunge basin of a great glacial waterfall, and also because in its environs is found the hart's tongue fern (*Phyllitis Scolopendrium*) which probably ranks as the most interesting and rarest fern in the United States.

Now it is proposed to acquire another lake of identical geological history, East Green Lake (also known as Blue Pond, and *Scolopendrium* Pond), which lies about a mile east of the west lake above mentioned. The pro-